Milwaukee Dock Eelgrass Restoration Update: Southern Depression Year 1 Monitoring, Lessons Learned, and Proposed Planting Plan for the Northern Depression

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Introduction

Efforts are underway to improve eelgrass abundance around Bainbridge Island, Washington, by restoring eelgrass habitat where two deep depressions were located on the old Milwaukee Dock site just south of Eagle Harbor. This work is being conducted in phases, first in the southern depression and then in the northern. At each depression, eelgrass on the margins of the depression is removed prior to fill operations to keep it from being buried. Next, the depressions are filled with appropriate sediment and allowed to settle. Finally, eelgrass is replanted on the new substrate. To date, all the eelgrass removal and fill operations have been completed and eelgrass has been transplanted to the southern depression. Replanting the northern depression is scheduled for the summer of 2015.

This progress report provides some observations and results from work conducted in the southern depression, evaluates lessons learned from the results from the southern depression, and proposes a planting plan for the northern depression based on the information obtained to date.

Southern Depression Planting Summary

In 2013, eelgrass plants taken from the margins of the southern depression were replanted on the new substrate in the southern depression. Advancing the science behind eelgrass transplanting was important to the Trustees so the plants were transplanted following an aggressive experimental plan designed to look at a number of variables that could potentially impact eelgrass survival including:

1. The season of planting (spring vs. summer)
2. The method of planting (TERFS vs. staples)
3. The origin of the donor plants (i.e., King County shoreline, edge of the Milwaukee Dock southern depression, or a mixture of the two origins)
4. Natural recolonization

The approximate positions of the different experimental transplant plots can be seen in Figure 1.

In 2014, just over 10,000 additional plants were planted along the offshore edge of the southern depression. These plants were removed from the edge of the northern depression prior to filling activities there and planted in the southern depression at the time of harvesting. These extra plants are not part of the experimental design but do add to the overall goal of increasing eelgrass coverage in the two restored areas.

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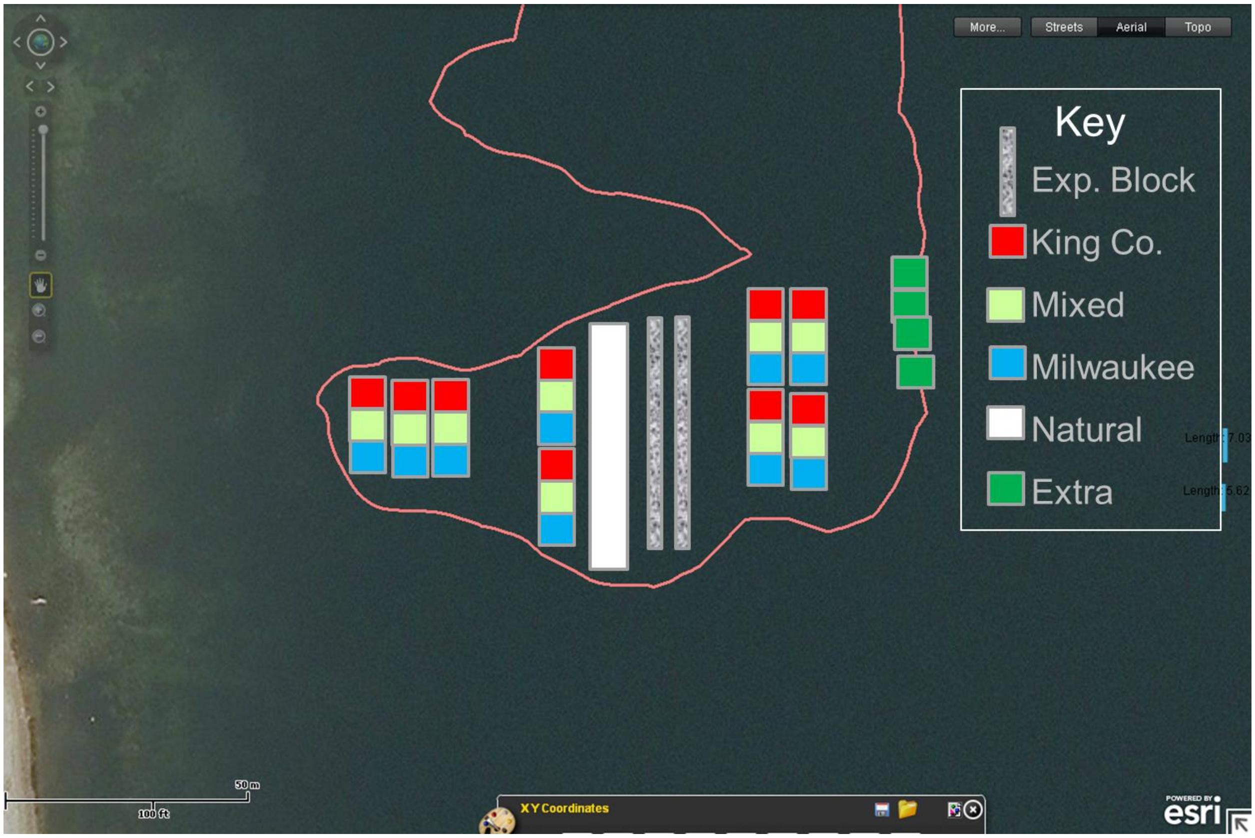

Figure 1. Approximate locations of experimental plots planted in the southern depression. The experimental block is where the seasonal and methods experiments were conducted. For reference, the multicolor blocks have been referred to as Clusters 1 - 3 from the left to the right (i.e., east to west).

Summary of Overall Observations from the Southern Depression

While this is only the first year of a multiyear monitoring effort, there are a number of observations made that have already changed the dynamic of the project and are being used to adaptively guide the project as it continues. Some specific data are provided in the next section, but a short discussion of these observations is warranted for perspective and context.

- Deposition of drift macroalgae was noted in many locations throughout the southern depression in low spots of the irregular bathymetry. This drift macroalgae appeared to inhibit the survival of eelgrass, probably through a combination of smothering/shading, physical disturbance, and the creation of anoxic conditions. While some drift macroalgae is normal in the area and even in the natural surrounding eelgrass bed, the irregular bathymetry created pockets of persistent deposition that led to the hostile conditions.
- The increased eelgrass mortality in these deposition areas created much more variability than normally seen in eelgrass restoration survival, and this increased variability will likely make statistics very difficult for the planned experimental treatments listed above (i.e., the power of the experimental design was greatly reduced).
- Plants further from the shore appeared do better than the plants closer to shore. This is likely due in part to the smoother bathymetry and therefore less persistent pockets of drift

macroalgae, but could also be a function of reduced reflected energy from the shoreline armoring or less exposure to breaking waves.

- The fill sediment was much less consolidated than the surrounding native sediment, and this may have affected how well the different planting methods could retain the eelgrass shoots before the rhizomes could develop sufficient anchoring power.   Storm/boat wake energy may have been able to dislodge the eelgrass more easily than in a more conditioned sediment. Uprooting of the eelgrass was common during the removal of the TERF frames because of the compromised anchoring ability of the substrate and many shoots had to be replanted by hand (without staples) during TERF frame removal.   Additionally, crabs appeared to like the new fill for burrowing and may have pushed eelgrass shoots out of the unconsolidated sediment. Crabs were observed to have burrowed under TERF frames and had undercut the sediment under the frame, removing the eelgrass rhizomes from contact with the sediment and preventing anchoring. These mechanisms may explain why more planting staples were noted lying on the surface of the substrate during monitoring dives than during similar monitoring at other restoration projects conducted by PNNL research divers that involved native sediment rather than fill material.
- The time required to compact the sediment likely compromised the experiments for the seasonal and methods treatments. Staple and TERF replicates were both planted in the spring just months after the fill operations concluded. The eelgrass planted at this time with staples was also the spring treatment in the seasonal experiment. Survival in these plants was very low to zero, but most likely a function of the time since the filling (and therefore compaction) and not season. Fill material was still less consolidated than the native sediment in winter 2015, but was markedly improved since spring 2013.

Preliminary Results

Again, these data are the result of one year in a multiyear monitoring effort and it may be too soon to draw definitive conclusions about the experimental treatments. Trends are shown here to add to the conversation, but the high variability makes significant differences difficult to see.

Overall, the average survival of transplanted eelgrass was very low (4.6% $\pm$ 6.6% [all errors are presented as 1 standard deviation unless noted]). The highest survival in any experimental plot was 27.8% but many plots had complete failure by the end of the first year. This mortality was due in large part to the drift macroalgae discussed above and survival appeared to be a little higher in plots with lower macroalgal cover (Figure 2), but the numbers are still lower than expected from similar studies. Additional factors such as the sediment compaction probably also contributed to the higher mortality.

Survival appeared to be slightly better on the offshore edge of the depression, a trend seen in the data when the experimental plots for the location of the donor material are aggregated into three “clusters” (Figure 3). Cluster 1, as seen in Figure 1, is the multicolored grouping of plots closer to the shore on the left, Cluster 2 is multicolored line in the middle, and Cluster 3 is the offshore grouping to the right. Overall the survival is low, but diver observations did note that the sediment was less irregular on the offshore side of the depression and that there were also larger areas devoid of marcoalgal deposition.

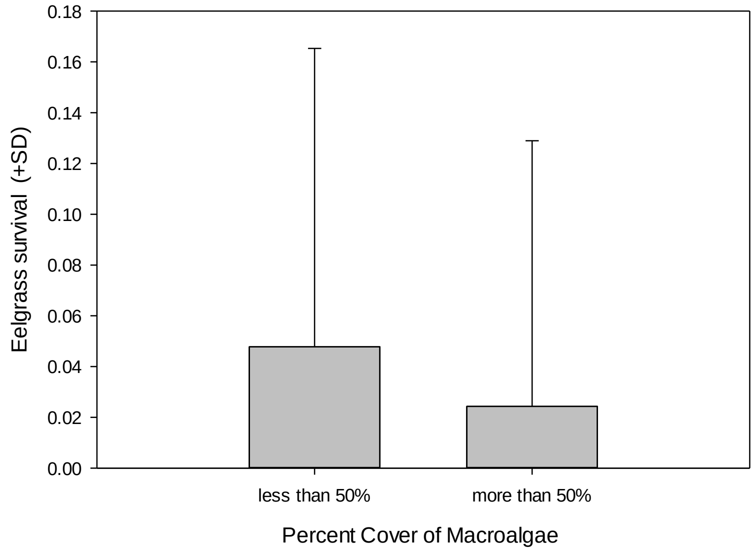

Figure 2. Average survival of eelgrass in the presence of macroalgae.

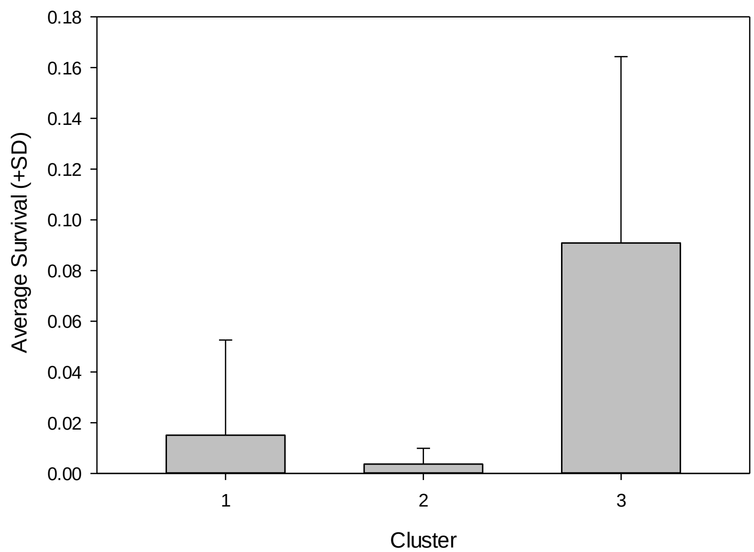

Figure 3. Average eelgrass survival in the three clusters. Cluster 1 is closest to the shore and Cluster 3 is furthest offshore.

In the treatment for the location of the donor stock, there is an interesting if not significant trend suggesting that mixing plants from multiple locations may provide a better chance for survival than using local plants alone (Figure 4). The variability is high in these data and it would be unwise to make any policy decisions based on the results, but it is suggestive that further study on the topic may be warranted.

The seasonal and methods studies experienced very high mortality in most treatments. The eelgrass planted on staples in the spring experienced near total mortality. The eelgrass planted using the TERFs had slightly better survival (3.5% ±10.6%) but much of this was as attributed to divers replanting unattached eelgrass found at the plots during their surveys. Eelgrass planted with staples in the summer did better (8.4% ±17.5%), and one plot approached 50% survival, but overall survival was still very low. There were two large swathes of drift macroalgae that cut across these plots and contributed to the high mortality.

Lastly, while no quantitative surveys have been conducted on the additional eelgrass from the fringe of the northern depression that was planted on the offshore edge of the southern depression in 2014 (see Figure 1), divers made qualitative observations in February 2015 and noted very high survival of that eelgrass. The plants looked very healthy even in their winter condition. There was some evidence of planting staples pulled from the sediment, but many such staples have stayed in in the vicinity with the eelgrass still attached providing a chance these plants could still potentially take root. Good eelgrass survival is likely at this location because these plants have made it though winter storms and the darkest part of the year, and are entering the most productive season when stressors are at their lowest.

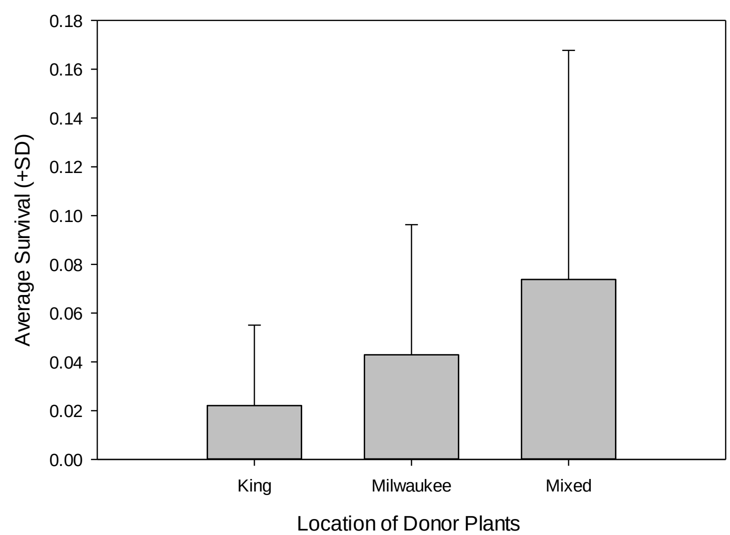

Figure 4. Average survival of eelgrass plants collected from different locations: King County, the Milwaukee Dock site, or a mixture of the two.

Southern Depression Lessons Learned

A number of lessons were gleaned from observations made over the last year and a half in the southern depression. These lessons will be used to adaptively manage restoration in the northern depression and are incorporated into the planting plan outlined below. In short, some of the important points are:

- Ensure during fill operations that the resulting bathymetry is as smooth as possible to prevent deposition areas that catch drift algae. Steeper slopes equal a greater likelihood of trapping material.
- Allow time for fill material to settle and compact prior to planting. This may increase the survival of transplanted eelgrass by increasing the anchoring potential of the site.
- Plant on high spots of any bathymetric irregularities and avoid the low spots/depressions where drift algae is likely to settle. Natural vegetative spread of eelgrass should colonize the depression over time if the conditions will support eelgrass, but planting higher on the substrate will maximize the chances for survival of the limited donor stock being transplanted into the area.
- At the Milwaukee Dock site, it is preferential to plant further offshore. Offshore areas likely have lower reflected energy from ferry wakes and storms from the armored shoreline and may also be less likely to accumulate the dense drift algae observed inshore.

Proposed Planting Plan for the Northern Depression

The northern depression was filled early 2015 using a slightly different method than used in the southern depression. A base layer of coarse sediment was used to make a more shallow depression that was then capped with a relatively thin layer of sandy sediment appropriate for sustaining eelgrass populations. The end result is generally the same although there are some areas where this base layer is expressed on the surface of the sea floor.

The transplanting of eelgrass from tanks at the PNNL Marine Sciences Lab to the northern depression will be approached differently than the planting in the southern depression. In the southern depression the focus was on the experimental design. This left the research divers with little latitude to avoid sites that may have been marginal (e.g., possible depositional areas). The primary goal of planting in the northern depression is to increase eelgrass. Research divers will therefore plant eelgrass in the most favorable locations based on the lessons learned to date on this project and their prior experience with eelgrass restoration.

In general, eelgrass will be planted toward the middle of the filled northern site (Area 2 in Figure 5). This location, on average, has gently undulating topography less conducive to accumulating drift macroalgae. Area 1 in Figure 5 indicates an area of increased irregularity with pockets of different sized sediment materials. Area 3 is the edge of the fill where the sediment type is too coarse for eelgrass and will likely lead to poor retention of the shoots. The edge of the fill area is close to the natural eelgrass bed and probably more likely to colonize naturally, making it a lower priority for transplanting.

Throughout the planting effort, divers will be guided by the lessons learned and choose the best areas within the planting region. Divers will avoid depressions that may trap drift macroalgae. Divers will also avoid areas were the more coarse basement fill has erupted to the surface. Divers will focus planting efforts on the offshore section of Area 2. Lastly, the divers will allow as much time as possible for the sediment to compact prior to planting. Instead of planting in the spring, the divers will plant in the late summer or early fall. Planting later in the season will also allow the research divers to conduct another round of monitoring at the southern depression and incorporate additional lessons learned, if necessary. With other projects it might be best to wait a year before planting to allow more compaction in the sediment, but the time constraints on this particular project do not allow planting to be delayed any longer.

Eelgrass will be planted using the staple method used successfully by PNNL in the past and for much of the project thus far. It appears this methodology can be successful in this location based on the success of northern depression eelgrass transplanted to the southern depression in 2014.

Although the initial plantings in the southern depression did not survive their first year as well as expected, much was learned about fill size and placement, timing of planting, and location of planting that is being incorporated into restoration of the northern depression. Adapting the plans for filling the northern depression and transplanting eelgrass to maximize survival based on what was learned at the southern depression should be a positive step forward for eelgrass restoration at this site. Sharing the lessons learned with managers of other eelgrass restoration projects will hopefully help to advance the science of eelgrass restoration in and beyond Puget Sound.

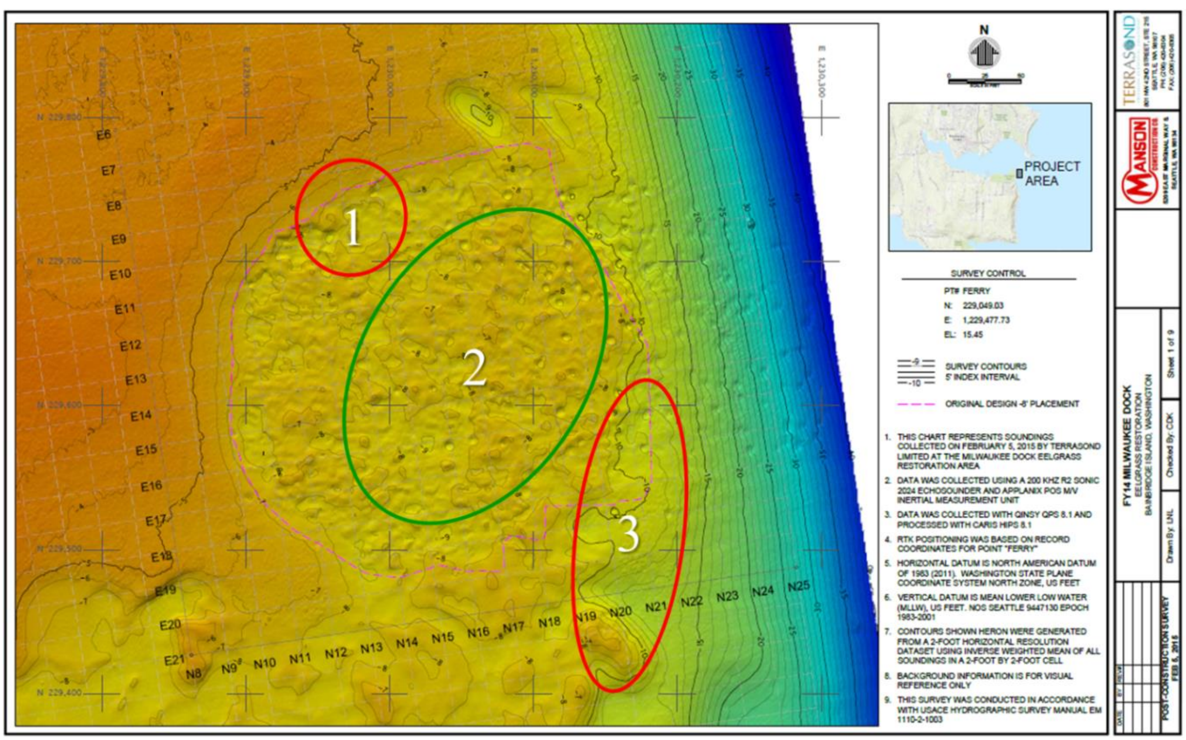

Figure 5. Reference for planting plan of northern depression based on the final survey results from the contractor.